Chapter 1 Overview of the MECO Experiment

Except for the cosmic-ray induced events in the TRIUMF experiment, which were later understood, neither of the experiments described in the previous section was background limited, LEAD TARGET. The incident muon flux is sufficiently high in all these experiments that the cosmic ray background scales with exposure time and not the beam intensity. In the SINDRUM2 experiment, there was no background at all in the $\pm 2\sigma$ region ($\pm$2 MeV) about 104.3 MeV, the muon conversion energy in titanium. The highest energy electron detected was 100.6 MeV, almost 4σ from the conversion energy, and this electron and those observed at lower momenta appear to come from muon decay in orbit, an irreducible source of electrons that can only be isolated by energy resolution. The SINDRUM2 authors conclude that this experiment demonstrates the feasibility of reaching their goal of $\sim 2 \times 10^{-14}$ if they can produce a μ^- beam sufficiently free of π^- and electrons.

We expect to improve on these experiments by a factor of 1000-10000 in the MECO experiment at BNL. The parameters of the MECO experiment are listed in column four of **Error! Reference source not found.**, and the differences that lead us to believe that such an improvement is possible are highlighted below.

- The muon beam intensity will be increased to 10^{11} Hz. High intensity is achieved in the same way as in the proposed muon collider. A graded solenoidal field is used, but with field varying from 2.5-5.0 T. The proton beam enters the production solenoid moving in the direction of increasing field, opposite the outgoing muon beam direction and away from the detectors. Pions and decay muons moving in the forward direction but outside the loss cone for the field gradient (~30°) will be reflected back by the higher field and will join the backward produced pions following helical trajectories, those with $p_t < 180$ MeV/c confined within the 30 cm inner radius of the magnet's shielding. A large fraction of the confined pions decay, producing muons which accelerate out of the low field region into the transport solenoid. The resulting efficiency is ~0.0025 stopped muons per incident proton.

- The beam will be pulsed to avoid prompt background, one bunch approximately every microsecond to match the negative muon lifetime in aluminum. The conversion electron is detected in a ~700 ns time window between bunches when, ideally, there is no beam in the detector region. The AGS will be run with two of six RF-buckets filled.

- The target in which the muons are stopped is situated in a graded solenoidal field and the detector is displaced several meters downstream of the target to a region of uniform field. The graded field varies from 2 T at the entrance to 1 T about 2 m downstream of the entrance. The increasing field encountered by electrons initially moving upstream reflects electrons back towards the detectors, resulting in large acceptance. Conversion electrons emitted at $90° \pm 30°$ with respect to the axis of the solenoid ($p_t > 90$ MeV/c for conversion electrons) are projected forward in helical trajectories of large radii that intercept the octagonal tracking detector. Beam particles and decay electrons at smaller p_t pass undisturbed down the center of the solenoid. The conversion electrons with $p_t > 90$ MeV/c reach the detector with $75 < p_t < 86$ MeV/c as a consequence of the graded field. Electrons with 105 MeV/c total momentum that are made in the beam upstream of the graded field cannot have transverse momentum greater than 75 MeV/c in the detector region, thereby eliminating many potential sources of background. By displacing the detector downstream of the stopping target, the solid angle for neutrons and photons produced in the target to reach the detector is greatly reduced. Further, protons produced in the stopping target can be attenuated with absorbers placed between the stopping target and detectors.

- The energy of the electron will be measured to better than 1 MeV (FWHM). Rejection of the background from muon DIO improves rapidly with the resolution because of the steeply falling energy spectrum. With 900 keV resolution, studies using GEANT predict this background in the region above 103.6 MeV to be one twentieth the signal for $R_{\mu e} = 10^{-16}$ (see Figure 9.8 **Error! Reference source not found.**).

Figure 1.1 is a schematic drawing of the proposed MECO experiment showing the production, transport and detector solenoids. The S-shaped transport solenoid transmits low energy μ^{-} from the production solenoid to the detector solenoid. High energy negatively charged particles and nearly all positively charged particles are absorbed in the collimators. The tracking detector shown here would be made from straw tubes oriented along the axis of the solenoid. An octagonal detector with 8 vanes extending radially outward, simulated with GEANT3, has been shown to provide good acceptance. The electron energy resolution determined from the same simulation is ~900 keV (FWHM), the uncertainty coming largely from fluctuations in the energy lost in the target and from multiple scattering. The simulation of the signal shape and the background from muon DIO are shown in Figure 9.8 **Error! Reference source not found.**.

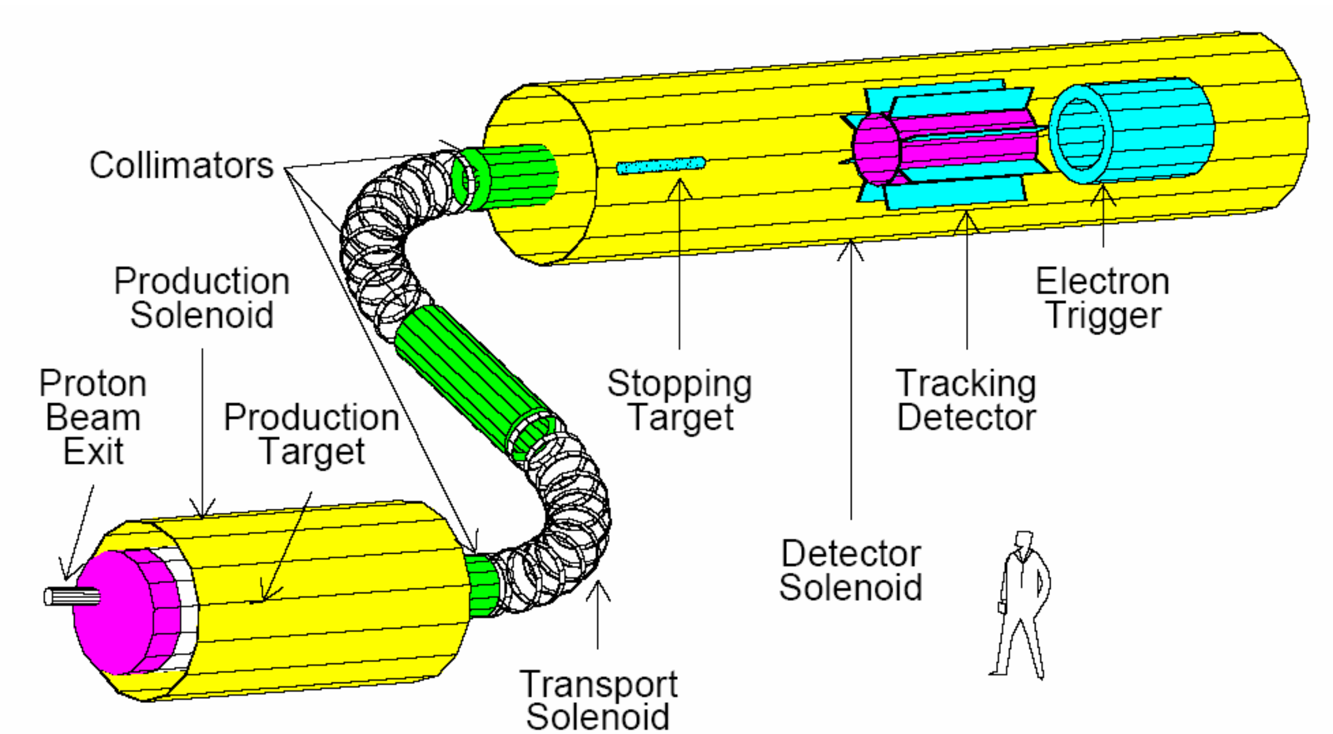

Figure 1.1: The MECO muon beam and detector system. The proton beam enters the production solenoid from the right side. The region of the interior of the solenoid system is evacuated; a thin beryllium window at the location of the second collimator separates the production and detection region vacuum and serves as a $\overline{P}$ absorber.